PEER REVIEW AND OPENNESS OF INFORMATION IN THE PROCESS OF MAKING ENVIRONMENTAL AND OTHER TECHNICAL DECISIONS

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I. Introduction

The question of how social decisions are to be made is as old as human society itself; the question of how decisions are to be made wisely is as old as philosophy itself; but the question of how technical decisions may best be made is comparatively new.

Throughout most of history, the social goal has been decisions considered morally righteous according to one canon or another; or which were held to be correct simply because pronounced by an infallible monarch. Then, as the divine rights of kings and clerics yielded to the age of reason, the goal in decision-making tended to shift from righteousness and infallibility to justice, fairness, and equity.

With the Industrial Revolution and age of technology, there arose a need for a new dimension in societal decision-making. The need was not altogether without precedent. When humanoids evolved into homo faber -- man the toolmaker -- it was necessary that spears and arrows were designed in such a way they flew straight, and that cutting and crushing instruments performed their intended functions. In the Middle Ages, it was necessary to design cathedrals in such a way they stood rather than collapsed of their own weight. But with the Industrial Revolution, there exploded in proportion to the explosion of technological capability a need for decisions which were true, not in a metaphysical sense, but in an objective sense; decisions based not on utopian thinking or dogma or pure logic, but on accurate foreknowledge of what the consequences would be. Should a factory be built upstream, close to the raw materials, or was the channel too shallow for

the larger ships required? Could a river be spanned, given the materials and bridgebuilding skill available? Where should roads be built in view of population trends? What type of roads in view of developments in transportation technology?

There is almost always a "social lag" between the rates at which technological and political institutions change. Industrial societies were generally slow to recognize that the new types of decisions being made had social implications so profound they could not safely be left to private entrepeneurs or private institutions any more than decisions in war could safely be left to generals. For decades, even generations, captains of industry were essentially free to build whatever kinds of factories, mines, railroads, or other facilities they wished, wherever they wished, and to operate them as heedlessly as they wished. Landholders could do whatever they wished with the land, lumbermen with the forests, hunters with the birds and beasts. Anyone could peddle any sort of food, drink, or medicine he could induce the public to buy. Anyone could do whatever he wished to the waters which adjoined or ran through his property, and to the air above it.

Eventually, governments of industrial societies were obliged to move into the area of technical decision-making. Sometimes they were forced to do so by a catastrophe which made it dramatically self-evident that private interests could not be trusted to make technical decisions for the public welfare. More commonly, governments were moved, by degrees, after extended prodding by social reformers who contended that it was not enough to react, piecemeal, to isolated disasters: there were problems of broad population

groups being injured or made ill by hazards and contaminants on the job; poisoned by nostrums and unqualified healers; dragged down physiologically, psychologically, economically. The reformers called for institutional changes.

Pure food and drug acts were passed; licensure laws covering physicians, dentists, hospitals, and other providers of health care; mine safety laws; restaurant sanitation ordinances; statutes of a hundred types undreamed-of in earlier times. But while passage of a local, state, or federal law might be the culmination of a political process, it was only the beginning of a technical process. To carry out a newly-enunciated public policy required a whole series of technical decisions. To say that foods, drugs, and cosmetics should be "pure" sounded straightforward enough; but someone had to define "purity" in myriad contexts, and continually redefine it as new products appeared and more precise measurements developed. To say that physicians and dentists should be qualified was easy enough; but how was such a desideratum to be translated into concrete terms? To say that places of employment should be "safe" said almost nothing; what were the criteria to be? Where was the fine line to be drawn between an acceptable level of safety and an unacceptable level of hazard?

Who was to make these decisions? To whom were they to be answerable? What was the process? What self-correcting mechanisms might it contain to take into account new evidence as it came to light? Many possibilities are imaginable; a number of them have been tried at various times, in various places, while some remain merely theoretical.

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A. <u>Decision-Making by Despots</u>

Some societies have attempted to engraft a superstructure of the new industrialization upon an old-style political substructure of authoritarianism. The ruler, or ruling clique, with power to pass judgment on economic, artistic, and all other matters, assumes omnicompetence to make scientific decisions as well. The results have usually been calamitous for the societies involved, and in some cases for millions of innocent bystanders. Hitler's ideas about biology were at the root of the destruction of the Third Reich; agriculture in the Soviet Union has still not recovered from Stalin's notions about plant genetics. At best, totalitarian societies languish in the backwaters. For many years to come, Spain and Portugal will be paying for the scientific stultification that accompanied the political "stability" of Franco and Salazar. Despite the alleged "efficiency" of authoritarian systems, the record suggests that despotism and technological progress do not go well together.

B. <u>Decision-Making by Technician-Politicians</u>

Some forty years ago, a movement known as Technocracy, Inc., enjoyed a substantial following. Technocrats argued that the technologization of society had barely begun, that it would be a dubious boon to mankind so long as decisions were made by persons without technical competence, but an unmixed blessing if decision-making were by persons with special scientific and technical aptitude, training, and experience. The Technocratic plan was rather like a 20th Century version of Plato's Republic, with scarcely more likelihood of adoption.

In an unorganized, attenuated form, however, the concept of the philosopher-king -- or, in contemporary terms, the technician-politician -- is

not beyond the realm of the possible. Technically qualified persons could run for public office against lawyers, bankers, farmers, housewives, actors, clergymen, and others. Physicians and engineers are occasionally elected to the legislative branch, and when this happens they are almost always appointed to committees on which they can bring to bear what is assumed to be their special expertise. But physicians and engineers are not scientists. Scientists seem virtually never to run for office, outside of largely ceremonial positions in university communities. The reason may lie partly in the nature of the scientific temperament, which is uncongenial to the passion and hurly-burly of politics; and partly in the nature of popular attitudes, which incline to be skeptical of "eggheads" who wander too far from their cloisters, or fearful of "Dr. Strangeloves" thought to have uncanny powers and diabolical designs upon the universe.

C. Decision-Making by the Demos

The U.S. Constitution, as has often been pointed out, is republican rather than democratic in the strict sense of that word. It does not contain any provision for decision-making directly by the populace. Some state constitutions do, however, through the processes known as initiative and referendum. The same processes are available in many cities, counties, and special election districts. These processes may be, and with increasing frequency are, used for the resolution of technical issues. For example, in many local jurisdictions the question of whether to fluoridate the water supply, rather than being decided by the health department, city council, county supervisors, or directors of the water district, has been referred to the voters. Sometimes they approve, sometimes they disapprove, sometimes they change their minds.

In California, in 1972, various environmental groups obtained enough qualifying signatures to place an omnibus Clean Air Initiative on the statewide ballot. It was soundly defeated. In the same state, this year, an initiative dealing with nuclear safeguards was voted upon; it lost equally decisively. In Oregon, Washington, Wisconsin, and other states, decision-making by initiatives and referenda has sometimes had results more to the liking of the sponsoring environmental groups.

The populist philosophy, which undergirds the initiative and referendum process, is attractive enough: since all the people are going to be affected in one way or another by broad environmental decisions -- e.g., whether to use public monies primarily for mass transit or freeways -- all the people ought to have the right to participate directly in such decisions; the initiative or referendum process affords the opportunity to educate the electorate in a way which the legislative process does not; a public policy will be more effective if it is well understood by the people whom it affects.

In actual practice, environmental and other technical decision-making at the ballot box does not usually come close to the foregoing ideal. Measures tend to be drawn by ideologues rather than scientists; complexities tend to be reduced to the kind of simplistic sloganeering that can be summed up on a billboard or bumper sticker; and decision-making by direct ballot requires that issues be reduced to a dichotomy. Elections, by their nature, do not permit in-between positions, qualifications, negotiations. The voter must either accept a ballot proposition whole, or reject it entirely. Technical decisions are rarely so clear-cut.

D. Decision-Making by the Legislative Branch

Strict constitutionalists might argue that the "republican" system created in 1789 is the best safeguard against demagoguery in environmental and other technical decision-making, and at the same time against usurpation of decision-making by any sort of elite. Carried to its ultimate conclusion, this point of view would call for legislative bodies not only to set broad public policy on environmental and other issues, but to fill in all the technical details and interstices. Presumably, legislators themselves would not do all the research required; the great bulk of it would be done by committee staffs in much the way the legislative process presently operates.

Again, it is necessary to distinguish between what is theoretical and what is real. In theory, Congress could not only legislate the general principle that drugs should be unadulterated, effective, and safe when used as directed, but could promulgate lists of drugs which did and did not meet these tests. The role of the executive branch would then be limited to enforcement. This is perhaps not far from what the founding fathers had in mind; if citizens were aggrieved by technical decisions, they would have readier access to legislative decision-makers than to those in the labyrinths of the executive bureaucracy.

But the reality is that legislative bodies are not equipped with the staffs, laboratories, and other resources necessary for informed technical judgments, and the further reality seems to be that legislative bodies have no desire to take on such responsibilities. There is political peril in decision-making, and there appears to be special political peril in environmental decision-making.

In addition to everything else, a case can be made that technical decisions should be removed farther from, rather than moved closer to, the arena of political pressures. The founding fathers could not possibly have foreseen the complex scientific issues with which the Federal government would be contending in the 20th Century. If they had, they might well have concluded it was better for technical judgments to be made by civil servants than by congressmen more interested in the next election than in scientific truth.

E. Decision-Making by the Judicial Branch

Among the three branches of government, the one generally considered most dispassionate, most independent of political, economic, or other pressures, is the judiciary. Since dispassion and independence are among the hallmarks of science, it is sometimes thought that scientific and technical decisions can better be entrusted to the judiciary than to either the legislative or executive branches. It may be true that a court is usually more objective than a legislature, but that does not mean the judiciary is totally above the battle. As will be seen in a subsequent section, Federal agencies were propelled into pesticide safety regulations by court action brought by proponents of such regulations; when opponents did not like the results, they went to a court they suspected would be "friendly" and got them set aside. Which court acted out of scientific considerations? Probably neither.

There seems an increasing tendency to go to court over environmental and other technical decisions, almost regardless of the issue, and the quality of the evidence on which it is based. Formerly, this was a prerogative largely reserved for industrial associations, since court appeals are costly. But as environmental and citizens' groups gained in strength

and resources, they began making more frequent use of judicial processes: seeking writs of mandamus if they felt laws were being enforced improperly; seeking what they considered proper interpretation of the laws; appealing to higher courts if decisions by lower courts went against them.

There can be no question these are protected rights of recourse available to anyone who can hire attorneys or attract volunteer attorneys. But there can be a question whether scientific issues can best be settled in an adversary setting; a question whether the judicial system was intended to dispense technical wisdom as well as justice; a question whether the courts are any better equipped, or as well equipped, as the other two branches of government to do the amount and kinds of research requisite to well-considered technical decisions; a question, in short, whether the tendency to force the judiciary into technical decision-making is good for the clients affected by those decisions, good for science, good for the courts themselves, or good for society-at-large.

F. Decision-Making by "Countervailing Forces"

Some might go so far as to hold that there is inevitably an adversary element in all environmental and other technical decision-making -- that somebody will be hurt, no matter how the decision goes -- and that therefore it is just as well to cut through all cant about dispassion and let the process be one of unvarnished struggle and power. Some labor unions, for example, do not care to rest occupational health and safety with government agencies; they feel they can do a more conscientious and effective job on behalf of their membership at the bargaining table.

There are at least two shortcomings in this approach to technical decision-making. First, a decision on a matter such as occupational safety

ought not to be based on considerations so ephemeral as who has the power, at a given moment, to bring the other side to its knees. If five particles per cubic foot of air is a scientifically validated Threshold Limit Value for asbestos or some other contaminant, it adds nothing significant to worker health for a union to bludgeon management into a contract calling for one particle per cubic foot, and may merely force management out of business. On the other hand, if management happens to be in the ascendancy, it is obviously improper for a contract to permit twenty particles per cubic foot.

Secondly, mechanisms simply do not exist for the resolution of most environmental and technical questions through the interplay of "countervailing forces". The process of collective bargaining between management and labor is extremely limited in its application, and has no counterpart elsewhere in society. Thus, for example, there is no way for nuclear power proponents and opponents to arrive at a decision between themselves. Their differences have to be referred to some other institutional arrangement for resolution; several possibilities have already been discussed above. In a sense, Alternatives C, D, and E are variations on the "countervailing forces" approach. They may be thought of as forms of compulsory arbitration; after the contending sides make their presentation, a decision is rendered by the arbitrator -- either the public-at-large, the legislature, or a judge.

G. <u>Decision-Making by Administrative Agencies</u>

Leaving aside a variety of improbable or undesirable decision-making processes, and various possible combinations and permutations, there remains a major possibility: technical decisions may be arrived at through a lengthy process which begins with a legislative mandate, includes the opportunity for judicial review at the end, and, in between, involves

extensive staff and line work by an administrative agency -- frequently by more than one agency.

This is a shorthand description of the way technical decisions are most often made in the U.S. at the present time. It is time consuming and cumbersome; it does not necessarily yield decisions which are scientifically defensible; sometimes it does not result in decisions which are defensible politically, economically, or in any other respect. But there is little point in speculating over radical changes at this time. For the foreseeable future, this is the principal method by which environmental and other technical decisions will be made if they are to be made at all. Since they must be made, and the need to make them will grow more overwhelming, not less, the most useful exercise for persons concerned about the quality of technical decision-making is to analyze the merits and demerits of present institutional arrangements, to build upon the strengths and attempt to correct the flaws.

Decision-making by administrative agencies is consistent with the democratic ideal inasmuch as responsibility can ultimately be fixed, and if the citizenry is aggrieved it can call the responsbile official to account. True, a cabinet member or other appointed member of the administration is not directly accountable to an electorate. But if his decisions create too great a storm of protest around the brow of the elected official who appointed him, he will probably not hold his position long enough to make many more decisions. And even if he rides out the storm, the administration of which he is a part will have to answer to the public at the next election. In some states and local jurisdictions, the citizenry need not even wait for the next regularly scheduled election. Jurisdictions which provide for the initiative and referendum usually add the process known as recall, whereby an elected official may be removed from office at any time a given proportion of the citizenry demands it.

All this is as it should be in a democratic society. But, as noted earlier, elected officials are almost never scientists, and, even if they were, they could not be expected to have competence in more than one field of specialization. In the very nature of the case, therefore, it is necessary for officials who bear the ultimate responsibility for technical decision-making to base their decisions on advice from others. Here, the technical and scientific staff of administrative agencies play the crucial role. They have the duty to provide the administrator with the information he needs to make the best decision possible under existing circumstances. If they provide information which is incomplete or inaccurate, the administrator has the right and the duty to reorganize his agency. Let us turn now to a consideration of some of the sources of data, and data-evaluation, which are available to an administrative agency.

II. Data-Sources in Technical Decision-Making

A. Depending on its legislative mandate, an agency may require data from those who will be affected by its decision. It may require an Environmental Impact Statement, for example, from a company which proposes to build a new plant, or a builder who plans to build a new subdivision. An agency may require that a manufacturer of a new pharmaceutical or pesticide submit many kinds of data as a precondition of licensing the product for sale.

B. To guard against the possibility that data furnished by a manufacturer may be self-serving, agencies sometimes have the wherewithal to perform research of their own. They may use this capacity to check the replicability of work done by others, or they may perform original research, methodological or substantive.

C. An agency may review primary and secondary sources which bear on the issue at hand: i.e., the background literature. Some large Federal agencies have brought this capability to a peak of high sophistication and refinement, making it possible to locate almost instantly all the references on a given subject in the scientific literature, not only in English but in most foreign languages.

D. An agency may conduct a public hearing, or series of public hearings. The point of departure may be a proposed set of regulations, which give the appearance that a decision has already been reached. But the proposed regulations may be a mere formality; the real purpose of the hearings may be the development of information and interpretations which did not come to the attention of the agency in other ways.

E. An agency may contract with an outside consulting firm or institution to examine some specific issue and gather certain relevant information if it does not already exist; prepare a "state of the art" summary; draw up a set of guidelines or recommendations; or simply devise a data-gathering instrument, such as a questionnaire.

F. An agency may appoint a "task force" or "working group" to address some ad hoc problem, and submit a report. Ideally, the members are chosen because of their special knowledge of the problem; in practice, professional, regional, or other "balance" sometimes becomes a consideration.

G. Several of the foregoing sources of data, and interpretations of the data, involve what may be called "scientific input".[1] Scientists have

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[1] At certain points in the discussion, for variety of expression, such terms as "scientific" and "technical", "science" and "technology", may be used almost as if they are interchangeable. They are not, of course. Science exposes; technology disposes. No environmental or other decisions of the type under discussion here are scientific decisions; nor are the decisions of peer groups. A scientist qua scientist might develop a new vaccine; a peer group might judge him worthy of financial support, and might in time recommend that the vaccine be used in a mass immunization campaign; an administrator might make the technical decisions as to who would give the injections, who would receive them, in what order of priority, on what date, and so forth.

the right of appearing at public hearings along with laymen; pre-registration data submitted by pharmaceutical manufacturers are presumably the work of scientists; consulting firms may subcontract with chemists, physicists, biologists, sociologists, or other appropriate specialists; "task forces" are often comprised largely or wholly of scientists. But none of the sources mentioned to this point quite meets the criteria of the most disinterested, most systematic form of "scientific input" available. For want of a better term, that form will be referred to here as "peer review".

III. The Meaning of Peer Review

"Peer" in the sense of a nobleman is a usage peculiar to Britain, and is antithetical to our meaning here. "Peer", deriving from the Latin par, means one who has equal standing with another. When we say a person is judged by a jury of his peers, we mean that all persons are equal in the eyes of our jurisprudence. When we say that scientific data or conclusions are reviewed by peers, we mean that they are evaluated by persons at least as well qualified as the persons who generated the data or formed the conclusions in the first place.

There may be a difference of opinion as to who is equally well qualified and who is less well qualified. Professional in-groups do not like to be judged by anyone who is not a member of the in-group; as Shaw put it, "Every profession is a conspiracy against society." Thus, for example, physicians are extremely resistant to having their decisions reviewed by non-physicians. In matters limited strictly to patient care, this point of view is generally honored in Medicaid, Medicare, and all other health programs in our society. But to the extent that the physician functions in any other capacity, the conception of "peer" shifts. If he functions as a businessman, he may properly be judged by accountants and others qualified to evaluate business affairs. If he undertakes medical research, his methods and findings may properly be assessed by physiologists, pharmacologists, statisticians, or others with expertise appropriate to his particular research problem.

For our purposes, then, the word "peer" has mostly generic meaning; it is largely situational. The "peers" who are qualified to evaluate a decision in solid waste disposal are probably not the same as those best qualified to evaluate sewage disposal; peers qualified to judge a decision about chlorinated hydrocarbon pesticides are not necessarily qualified to judge decisions about organic phosphorus compounds. College and university degrees are no sure

indicator. A Ph.D. in a scientific field of inquiry is no guarantee that the holder is a scholar, has an open and inquiring mind, or even that he is a very good technician. Someone with an M.S. may be a better scientist, operationally; or, conceivably, someone with few formal scientific credentials may be the peer of a full professor. An attorney who specializes in environmental cases may, over the years, learn as much about the relevant disciplines as persons with graduate degrees in environmental science.

For the moment, however, there exist no satisfactory means for appraising purely individual qualifications for peer status. It would be very difficult for an attorney, or novelist, or historian to enter the scientific pantheon. Normative rules of thumb are generally employed. A doctorate is considered a better qualification than a master's degree; a doctorate from Harvard or UC Berkeley is considered better than one from a smaller university; tenure on a faculty is usually more qualifying than experience in private industry; tenure on a prestigious campus is more qualifying than tenure on a less prestigious one; publications in general are qualifying, but appearances in some journals is considered preferable to others.

The second word in the phrase we are endeavoring to define is "review". The dictionary definition, again, is helpful, but not all-sufficient. For our purposes, the concept not only implies a critical study of work done by someone else, but that this critical evaluation be done on some kind of systematic footing. In a sense, a biochemist is conducting a form of "peer review" every time he takes off an hour or two from his other activities, thumbs through one of the journals in his field, and thinks to himself that a certain piece of research was well conceived and conducted, and another not so well done. Such opinions may be communicated haphazardly to colleagues over coffee, and eventually, at fifth or sixth remove, find their way to the persons who con-

ducted the research in question, or to those considering conducting similar research, and may be taken into account. But chances are the opinions will be lost and be of no effect.

If that same biochemist were to write a letter to the editor of the journal stating his opinions and the reasoning on which they were based, it would come closer to "peer review". But there would still be many imponderables. The biochemist would be under no obligation to write regularly; the editor would be under no obligation to print the letters; the scientists who did the original research or were thinking of conducting similar research, might not read the letters.

Peer review, as we shall employ the phrase, reduces imponderables to a minimum. The participants in the process do not evaluate the evidence or neglect to evaluate the evidence, as they please. If they agree to participate, they read what is necessary, attend whatever meetings are necessary, render their opinions in whatever form is necessary for the fulfillment of their commitment. To obviate the possibility of misconstructions, opinions are often put into writing; if made orally, they are usually recorded by a secretary, or at least paraphrased in the form of minutes, and the minutes circulated for correction of omissions or errors.

Next, the process of orderly peer review requires that the opinions of the reviewing peer or group of peers be communicated without fail to some appropriate decision-making authority, and that the decision maker actually read or listen to these opinions. He may be an editor, an administrator, whatever. The process does not require that he accept the opinions. If it did, advisors would become decision-makers, and administrators would become mere figureheads. As noted before, there are sound reasons why this would not be feasible or desirable in our type of society.

But it is more than desirable in our type of society -- it is vital -- that administrators who are responsible for making decisions about environmental and other technical issues not only receive the best available scientific evidence and opinions, but that they understand it. Which suggests another element in the concept of peer review as we are here using the term; the process should yield a body of recommendations which are well organized, well documented, and couched in language comprehensible to the person or persons to whom addressed.

Another element in peer review, as comprehended here, is so important it cannot be overemphasized. The concept, like the concept of science itself, is inherently incompatible with secrecy and spurious "confidentiality". Discretion is sometimes appropriate to avoid needless personal embarrassment; it is legitimate, for example, that the scientist who submits a paper for publication in a scholarly journal not be told the identity of his peer or peers who evaluate it.

But there can be nothing secret in the contents of the paper; nothing withheld concerning the research on which it is based. A quintessential ingredient in peer review, as we conceive it, is that it opens up the field of inquiry involved, and the methodology employed, to any and all other interested scientists. Valid scientific evidence must be replicable, and there is no way for others to check the quality of the original research by repeating it save through full disclosure.

For example, research concerning the toxicity in laboratory animals or human health effects of some hazardous material should be considered unacceptable for publication in a scientific journal, discussion at a scientific meeting, or any other form of peer review, if the name of the material or chemical composition is suppressed or disguised as a "trade secret". Similarly, it should

go without saying that research is not scientific in any legitimate sense of the word, and should be rejected out of hand in any peer review process, if a portion of the data is withheld by the investigator because he deems it "irrelevant" or for whatever reason. It is for his peers to judge such matters. All the evidence must be in full view, and if some of it does not support the investigator's hypothesis, that is the way of science, and of peer review.

The compelling necessity for openness in the peer review process -- the matchless virtue in the process itself -- is that it is self-correcting. To paraphrase Jefferson, error of method or interpretation may be tolerated where peers are free to combat it, through methods and interpretations of their own. There is a danger in the peer review process, if the peer group grows ingrown, rigid, snobbish, self-protective. The cure is to keep the peer group itself open, even as the results of its deliberations should be open.

There are other ways in which the peer review process may be deflected or subverted. Peers are not immune to cultural values, family pressures, or other extra-scientific influences upon their judgment. It is conceivable that a group of peers -- an advisory committee to a Federal agency, let us say -- may happen to share a common distorting predisposition. In the short run, such a peer group may influence the decision-making of the agency in the direction of one particular point of view or the other. But if their activities are open to the scrutiny of colleagues outside that advisory committee, outside that agency, the process of peers reviewing peers may be expected to work in subtle ways to correct excesses of prejudice and partisanship. The lone scientist is a fiction; a scientist may almost be defined as one who continually sharpens and modifies his intellectual tools through contact with his fellows.

At its best, then, peer review is self-correcting, and if employed appropriately by administrators as part of the process of making environmental and other technical decisions, may be self-correcting for society as a whole.

IV. Examples of Peer Review

The following examples of the peer review process as it operates in various situations are intended to be illustrative rather than exhaustive.

A. In the world of scholarly and technical journals, "peer review" has a specialized meaning. When an author submits an article, the editor or editorial committee decides on a referee or panel of referees who are felt to have special expertise in the area covered by the article. They are asked to judge whether the contribution should be published intact; published with minor modifications; published only after major rewriting; or rejected altogether. Customarily, the evaluation is not done "blind"; that is, the referees know the identity of the author. The author, however, is not told the identities of the referees. He knows only that they are supposed to be his peers. The system sometimes gives rise to suspicions of cronyism; sometimes a scientist working in a new field of inquiry, or in an unfamiliar way, may question whether referees from more conventional areas and methodologies are truly his peers. But, in general, the system works as well as any which can be envisioned. If it leans, it is more likely to lean in the direction of publishing some marginal contributions rather than denying publication to those worthy of it.

A variation on this form of peer review, and one which is even sounder in some respects, consists in the presentation of papers at scientific meetings. At major conferences and conventions, these are refereed in advance by a program committee. They are often, though not invariably, submitted subsequently for publication in a suitable journal. The advantage of presentations at scientific gatherings over all other forms of peer review is that the quality of the work is evaluated not only by an editor or small group of referees, but by an entire audience of the investigator's peers. At well-organized scientific meetings, adequate time is allowed for discussion from the floor.

There is often, in addition, a discussant or panel of discussants who have studied the paper, in advance, and are prepared to initiate the discussion and to stimulate it if it lags.

B. The term "peer review" enjoys wide currency in the field of medical care, with another special, limited meaning. In this context, it refers to evaluation of the judgments of physicians, usually after the fact, by committees of their fellow-physicians. Major hospitals, for example, have "tissue committees" which decide, on the basis of biopsy material, whether surgical procedures were indicated. A surgeon whose judgment is repeatedly shown to be faulty will likely be spoken to privately; if his judgment proves faulty flagrantly and frequently, his hospital privileges may be withdrawn. Most hospitals also have committees which review admissions, length of stay, and discharges.

Medical care programs financed in whole or in part by tax revenues are increasingly using peer review in an effort to ensure that quality of care is maintained, while, at the same time, preventing the waste of funds.

C. The National Institutes of Health, and other Federal agencies in a position to disburse research grants, make extensive use of peer review both in the awarding of the original grants and in the supervision of research in progress.

After administrative processing, an application is submitted to a "study section" composed of experts in heart disease, occupational safety and health, or whatever the field of research in which the applicant proposes to work. Each application is first voted on yes or no, and then assigned a priority rating, which determines the sequence for funding rather than a flat recommendation to fund or not to fund. The number of projects funded by the agency will depend on the money available; the agency is expected to begin with the

projects given the highest priority ratings, although under extraordinary circumstances, the administrator has latitude to overrule the judgment of a study section.

D. Elsewhere, peer review mechanisms may be less highly formalized, but there are no professions without some semblance of the process. A professional person's special competence is the product of professional peers. He is trained as a lawyer, or architect, or engineer, or political scientist, by lawyers, architects, engineers, or political scientists. In a field requiring licensure, he is licensed by a board consisting largely if not entirely of professional peers. And it is hardly possible to have a career in any profession without contacts with one's peers. In the course of these contacts, it is hardly possible to escape being judged. The judgments may be formal, as when an attorney violates the ethical codes of his profession, is tried by a committee of his bar association, and disciplined. At the very least, an informal sort of peer review goes on constantly. A trial lawyer is judged highly in the eyes of his colleagues if he accepts difficult cases and wins them; he is judged poorly if he takes easy cases, and loses them. Even judges may be judged -- by the quality of their decisions, and by the frequency with which they are sustained by higher courts.

V. Forms of Peer Review Available to EPA

The Environmental Protection Agency has a number of forms of peer review at its disposal to advise and assist in the decision-making process. Some have already been adumbrated in the more general discussion above.

A. To the extent EPA dispenses research grants to independent investigators, it utilizes essentially the same system described in section IV-C.

B. In the promulgation of all but emergency regulations, EPA conducts public hearings to which scientists are invited. While not a form of peer review, per se, any testimony which scientists give on such occasions invites scrutiny by their peers; their professional reputations to some extent are at stake.

C. EPA's own scientific personnel -- for example, at Triangle Park -- conduct research, and write for publication. Certain in-house publications are not refereed by external peers. But anything submitted to a regular scholarly journal is, of course, subject to the peer review process described in section IV-A. EPA has ready access to all the relevant literature, by its own scientists, and others as well. Through a highly sophisticated reference retrieval system.

D. Although there is some jealousy and secrecy between agencies, and even within agencies, scientific work by EPA's staff is subject to review by peers in the Department of Labor, Department of Agriculture, Department of Interior, and other agencies with an interest in some specific environmental issue, just as the scientific work of these other agencies is presumably subject to review by peers in EPA. Coordination is available through such interagency groups as the Council on Environmental Quality.

E. EPA is able, when it wishes, to convene open symposia, or invited-input symposia, at which qualified persons review the evidence bearing on some

decisions confronting the Agency, point out the lacunae in existing knowledge, recommend ways in which these lacunae might best be filled.

F. Under some of the laws which affect it, EPA is required to seek the advice of qualified advisory groups or of the National Academy of Sciences during the decision-making process. Under other laws, consultation with NAS is optional with the Administrator. For example, under a 1972 rewriting of the Federal Insecticide, Fungicide, and Rodenticide Act (sometimes known as the Federal Environmental Pesticide Control Act), "Upon the request of any party to a public hearing (following cancellation of a pesticide registration) or when in the Hearing Examiner's judgment it is necessary or desirable, the Hearing Examiner shall at the outset of the hearing refer to a Committee of the National Academy of Sciences the relevant questions of scientific fact involved in the public hearing. Each such committee shall include qualified scientists not more than one-third of which shall have an economic interest in the chemical industry. None of the members of such committees shall have any economic interest in the pesticide which is the subject of referral. The Committee of the National Academy of Sciences shall report in writing to the Hearing Examiner within 60 days after such referral on these questions of scientific fact. The report shall be made public and shall be considered as part of the hearing record."

G. EPA makes extensive use of consultants and "task forces". To the extent they function sui generis, they are not a form of peer review (although their work may, in turn, be reviewed by other peers). But to the extent they openly appraise work already done, inside or outside EPA -- and that is often the principal thrust of "task forces" -- they may properly be regarded as a type of peer review.

H. At its inception, on December 2, 1970, EPA took over Advisory Committees on Environmental Radiation Exposure, Air Pollution Control Techniques,

Air Quality Criteria, and Air Pollution C hemistry and Physics from the Department of Health, Education and Welfare. On May 21, 1971, an Advisory Committee on Hazardous Materials was created by EPA Administrative Order No. 1130.3B. Five more Advisory Committees have subsequently been added: Ecology, Environmental Health, Environmental Measurements, Environmental Pollutant Movement and Transformation, and Technology Assessment and Pollution Control.[2]

Since January 11, 1974, all of EPA's Advisory Committees have been coordinated by a Science Advisory Board (SAB) with an executive committee consisting of the chairmen of the individual committees plus some members-at-large. SAB has a secretariat independent of the staffs of the individual committees. Among other things, SAB is intended to provide "a strong link between EPA's Administrator and the scientific community" and "independent review and advice on EPA's major scientific programs"... It is to "advise on broad scientific, technical and policy matters; make recommendations concerning needed research and development activities; assess the results of specific research efforts; assist in identifying emerging environmental problems; provide advice with respect to the Agency's relations with other governmental agencies, citizen groups, industrial groups, and educational institutions; and assure the cohesiveness and currency of the Agency's scientific program."[3]

Taken together with the ten individual Advisory Committees, this seems tantamount to a charter for peer review of all EPA's scientific activities. Every one of the essential ingredients appears to be present: members of these advisory groups are drawn from outside the Agency; they are authorized to advise

[2] One on Meteorology has been dropped; another, on Drinking Water Standards, has been replaced by a statutory committee under the Safe Drinking Water Act.

[3] EPA Order 1130.30A.

on research which the Agency should support, in the manner of a study section; to evaluate the quality of work already in progress; to draw conclusions from the evidence, and make recommendations on policy matters.

In 1975, SAB had a budget of $250,000; the Hazardous Materials Advisory Committee a budget of $227,000 and six full-time staff positions; the Ecology Advisory Committee a budget of $110,000 and 3.5 staff positions; other Advisory Committees somewhat smaller resources. Each of the ten committees is chartered for fifteen advisors, but not all positions are filled at any one time.

It would seem that the SAB is the capstone in a rich variety of peer review potentialities available to EPA for use in its scientific activities and technical decision-making. Let us turn now to the question of how effectively EPA utilizes these potentialities.